The Development of an Augmented Virtuality for Interactive Face Makeup System

Bantita Treepong(✉), Panut Wibulpolprasert, Hironori Mitake, and Shoichi Hasegawa

Department of Information and Communication Engineering, Tokyo Institute of Technology, Tokyo, Japan
{treepong.b,panut,mitake,hase}@haselab.net

Abstract. In this paper, we focus on developing an interactive face makeup system that allows the user to practice applying makeup on their face without using real makeup materials. In our system, feature points on the human face were tracked by Kinect and mapped to a 3D face model. Face textures were generated and mapped on the model by using UV mapping technique. The makeup tools were developed for providing tangible interactions to users. Users can perceive a realistic makeup feeling by using our makeup tools. When the user applies the makeup, the program will paint the color on a face model, which synchronized with the users' movement in real-time. The system is evaluated by a subjective evaluation method. The result shows that our system can provide a new and attractive makeup experience to the users compared to other makeup applications.

Keywords: Face makeup · Augmented virtuality · Tracking system

1 Introduction

In our modern society, makeup is one of the main contributors of human beauty. There are more than 88 billion views of beauty contents consist of makeup tutorials and review of cosmetic products videos on YouTube [1]. This indicates that considerable amount of women pay attention to cosmetic. One in three women usually wears makeup every time before leaving the house and more than 50% of women feel that wearing good makeup helps them become more self-confident [2]. However, one basic issue is that they do not know which makeup material is suitable for their skin tone. They have to spend a fair amount of money to buy several makeup materials in order to find a suitable material. Moreover, sometimes they need to spend a lot of time with makeup before they step outside. In addition, women who have no makeup experience also feel that doing makeup is very troublesome.

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Nowadays, many interactive makeup applications have been developed, such as [3–5]. The simplest type of application is a 2D makeup application, for examples [6]. In this case, a camera is used for capturing the user's face. The user can select the makeup color and style through its 2D user interface(UI). However, this kind of applications is unattractive and inflexible because it just overlay your selected makeup on the captured image which can limit the user's viewpoint. Furthermore, the makeup styles, e.g. eyebrow shape, the thickness of eyeliner and the shape of cheek brush, are limited, so the user can not generate their own makeup style.

Another type of makeup application is smart mirror application, such as [7,8]. Here, the video camera is usually used for capturing the user's face and the makeup result will be overlaid on the captured video in real-time. Therefore, it will allow the user to see the makeup result in a different viewpoint. Furthermore, this kind of application uses the smart mirror as a display system instead of using the normal monitor. The smart mirror can fill the gab between virtual and real environment for providing the realistic feeling to the user. The common weak point of these applications is that the user can not improve their makeup skill. The applications provide only static makeup function that allows the user to select the makeup style through its UI. It does not provide the function for applying the makeup by themselves. Rahman et al. [9] also developed a smart mirror system for supporting the user in cosmetic products selection. They attached the IR emitter on their mock-up cosmetic tool for tracking the tool movements. A RFID tag also attached on the tool for indicating it's the texture and material. Before the users apply the makeup, they have to scan the tool to the RFID reader, then the system will generate a makeup texture on a 3D model based on the scanned product. They also provide a recommendation scheme that shows the information of the similar products of different brands. Though this system can help the users to make a decision support in cosmetic selection easier, the variety of makeup tools and color still limited depend on their developed cosmetic tools.

Besides, some researchers also developed a makeup application based on an augmented reality system [10,11]. For example, Almeida et al. [10] combine an AR technology in their makeup application on a mobile phone. This application uses AR for assisting a user to apply a makeup following the given tutorial. The user's face was captured and tracked by using a camera on a mobile phone. Then, a semi-transparent image of makeup is superimposed on the captured image in step-by-step for guiding a user to apply a makeup in a specific area. However, the application still needs a skin tone detection function which can help a user to be able to find a suitable cosmetic color with user's skin tone.

In this paper, we present the interactive face makeup system that allows users to practice the makeup on their face without the use of real makeup materials. The aim of this system is for supporting the makeup training when users have an extra time. By using this system, the users can try to apply makeup as many times as they want on the virtual face without the need to actually clean their face. Moreover, they can choose the makeup color which is suitable for their skin tone and try to find their makeup style by practicing with our system.

2 Makeup Survey

The makeup survey was conducted from 49 people with 94% of female and 6% of male. The age group of respondents is between 22–40 years old. The propose of this survey is to analyze the general makeup behaviors of people. The data of this survey is used for making a decision within a specified area of makeup. The survey is separated into 2 parts: the makeup in daily life and the difficulty of makeup.

In the first part, we ask about a simple makeup that respondents wear every day. The face powder, lipstick, and brush-on are the top three makeup materials that people usually wear in their daily life. In the second part, most of the respondents think that applying the shading and highlighting is the most difficult process of the makeup while applying the eyeshadow, eyeliner and shape the eyebrow are respectively the second, third, and forth. Table 1 shows the result of both first and second part of the makeup survey.

Table 1. The makeup survey result

Makeup process	Percentage	
	Everyday makeup	Makeup difficulty
Apply face primer	53	27
Apply face powder	84	10
Apply eyeliner	31	43
Apply eyeshadow	27	45
Shape eyebrows	47	39
Face brushing	57	12
Apply lipstick	71	10
Shading and highlighting	NA	47
Other	6	NA

3 Proposed Method

This section gives the overview of our proposed method. The system requirement is consists of a real-time face tracking and touch detection function of the makeup tools. For the real-time face tracking, most people usually deform their face for applying makeup in the exact area. Therefore, the face expression tracking process is essential for the makeup system. Also, the touch detection function is important because it can provide a realistic makeup feeling to the

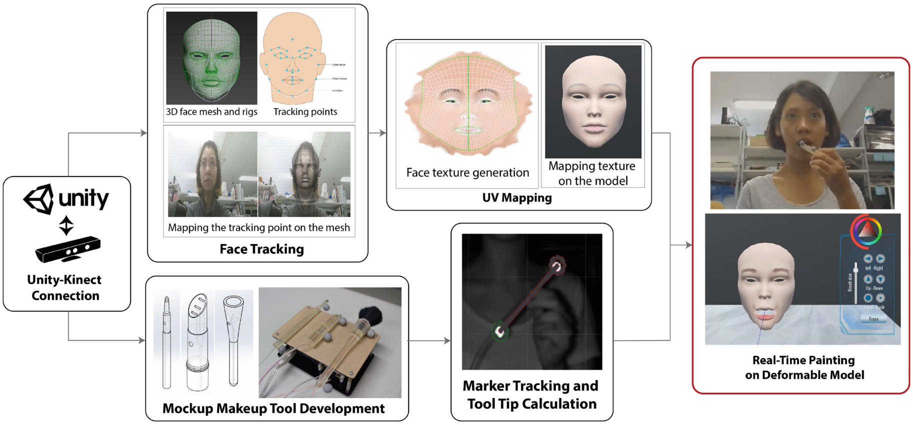

Fig. 1. The figure displays process overview of our method. They are separated into 3 parts: (1) Face tracking and UV mapping, (2) The development of the makeup tools, and (3) Real-time painting system

user. This function can help the user to feel and know which part of their face has makeup.

The system consists of a Kinect camera for capturing the movement of the human face in real-time, the mock-up makeup tools for providing the tangible interaction to the user when they apply the makeup, the Arduino Uno board, and the computer monitor. The process overview of our system is illustrated in Fig. 1. The propose of this research is to develop an augmented virtuality system to practice applying makeup. The user can experience a makeup feeling without the use of real makeup materials. By using this system, the user can improve their makeup skill and help them to be self-reliant with their own makeup style.

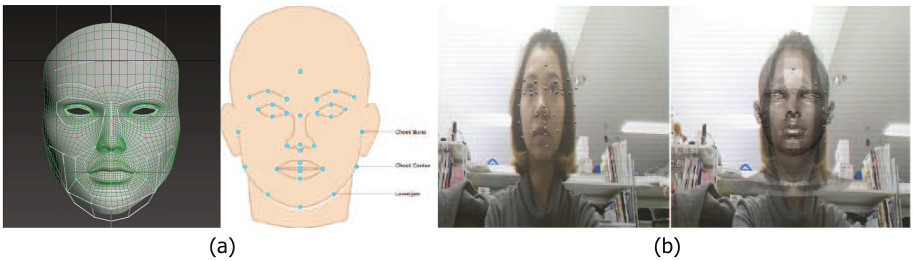

Fig. 2. (a) The 3D face mesh and the 33 feature points of the human face, and (b) The tracking points were mapped on the 3D face model.

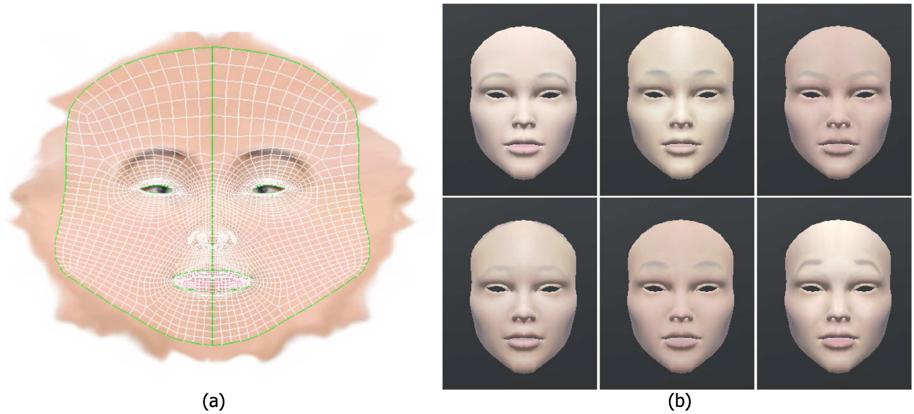

Fig. 3. (a) The captured image was mapped on the unwrapped uv texture, and (b) The mapping result of images that are captured form six subjects.

3.1 Face Tracking and UV Mapping

At the beginning, a 3D model of the human face is created in an Autodesk 3ds Max software. A hierarchical set of a facial skeleton of the model is generated by using rig system on a BonyFace plug-in for 3ds Max. The model is imported to the Unity software. The Kinect 2.0 is used for capturing and tracking the human face in this step. The 33 feature points of the human face including eye, eyebrow, mouth, nose, cheek, jaw, and chin, are tracked by using Kinect high detail face points function [12]. Those points are mapped to the facial skeleton of the model. Then, the face model will be able to move corresponding to the user's facial expression in real-time, as shown in Fig. 2.

To overlay the face texture on the 3D model, UV mapping technique, which is the process for projecting a 2D image to a surface of a 3D model, is used in this step. First, the mesh of 3D model is unwrapped by using the unwrap function in 3ds max. An image of the subject is captured and mapped onto the unwrapped UV for generating the face texture. Finally, the generated texture is applied on the model to see the mapping result, as illustrated in Fig. 3.

3.2 Development of Makeup Tools

For providing a tangible interaction and giving a realistic makeup feeling to the user, the makeup tools have been developed. As mentioned in the makeup survey section, we found that the lipstick, face powder, and brush-on are the top 3 makeup materials that people usually apply in their daily life. While shaping the eyebrow is also one of the difficult parts for makeup. As a result, in the preliminary step, we pick up lipstick, cheek brush, and eyebrow pencil as the focused makeup tools in our system.

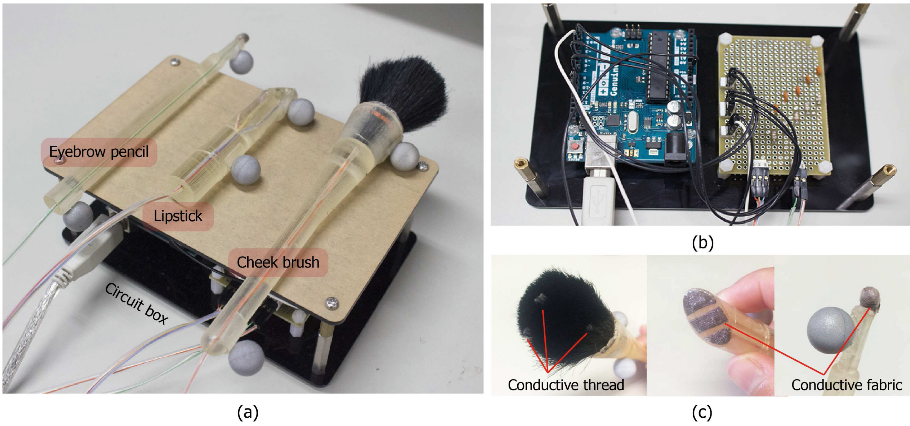

Fig. 4. (a) The hardware prototype includes of eyebrow pencil, lipstick, cheek brush, and circuit box, (b) Inside the circuit box consists of Arduino Uno, and low-pass filter circuit board, and (c) The conductive materials are attached on the tip of makeup tools.

Hardware Design. The prototype of the lipstick, eyebrow pencil, and cheek brush are developed, as shown in Fig. 4(a). The main part of the prototypes are the conductive materials which are used to detect touches between the prototype and the user's face, as can be seen in Fig. 4(c). The conductive fabric is put on the tip of lipstick and eyebrow pencil while the conductive thread is assembled inside the brush. When users brush their cheek or apply the lipstick by using our tools, the conductive materials will receive the touching data and send the data to the circuit board, as shown in Fig. 4(b), for filtering out the high frequency. The filtered data will be sent to the Arduino for processing and then the final data will be sent to the computer via serial port. For the lipstick, the conductive fabric was separated into 3 layers for detecting a different touch area and providing a different brush size in our face painting program according to the touch area.

Fig. 5. (a) Property of retro-reflective marker (b) Raw image captured from Kinect IR camera (left), and tracking result (middle and right)

Tool Tracking. The tool tracking system is developed for localizing the position of our makeup tools. The system consists of a Kinect camera and retro-reflective markers. The retro-reflective marker can reflect the light back in the direction where it comes, as depicted in Fig. 5(a). With this property, the position of the marker can be found by capturing its reflected light.

The Kinect IR camera is used for capturing the markers. The reflected area of the markers is tracked by determining the area of the white pixel in the captured video in real-time. The tracking results are shown in Fig. 5(b).

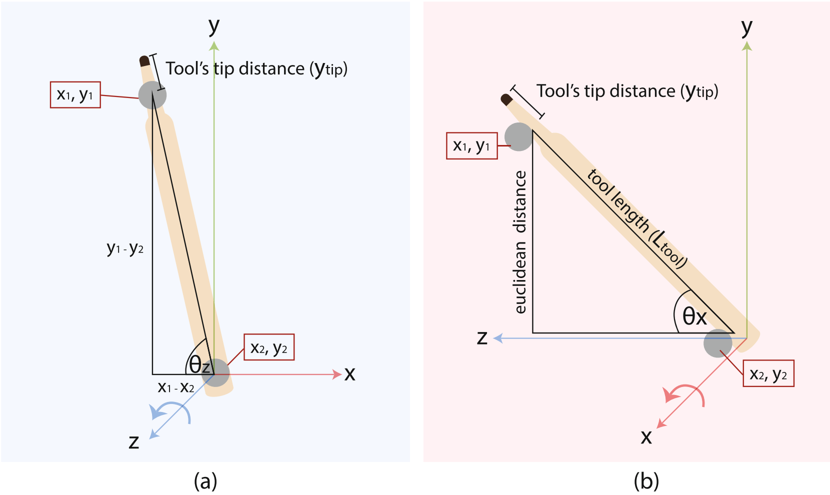

Fig. 6. The coordinate system and the relationship of marker and tool shows in front view (a) and side view (b)

Tooltip Calculation. Since the markers are not exactly attached to the makeup tool's tip, the tooltip calculation method is applied for calculating the relationship between the marker and the makeup tool's tip. First, the rotation angle of z-axis (θ_z) is calculated by using the slope data between the top and the bottom markers, as illustrated in Fig. 6(a), and the rotation angle of x-axis (θ_x) is calculated by using Euclidean distance and the length between two markers, as illustrated in Fig. 6(b). The angle can be described by (1). After the angles were calculated, the rotation matrix of z and x and the position vector of the tool's tip can be calculated by using (2), and (3) respectively.

$$\theta_z = \arctan\left(\frac{y1 - y2}{x1 - x2}\right), \theta_x = \arccos\left(\frac{\sqrt{(x1 - x2)^2 + (y1 - y2)^2}}{L_{tool}}\right) \quad (1)$$

$$R_{zx} = \begin{bmatrix} cos\theta_z & -sin\theta_z & 0 \\ sin\theta_z & cos\theta_z & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & cos\theta_x & -sin\theta_x \\ 0 & sin\theta_x & cos\theta_x \end{bmatrix} \quad (2)$$

$$P_{tooltip} = R_{zx} \begin{bmatrix} 0 \\ ytip \\ 0 \end{bmatrix} + \begin{bmatrix} x1 \\ y1 \\ z1 \end{bmatrix} \quad (3)$$

3.3 Face Painting

The final step is the development of face painting system for real-time painting on a deformable model. The system is developed using a Unity3D framework. The workflow of the system is shown in Fig. 7. First, when a user applies the makeup by using our makeup tools, the conductive materials which are used as the touch sensor will detect if the tool has touched on the user's face or not. When the tool is touching, the software will project a ray-cast according to the tracking position of the tool's tip. Once the ray-cast hit a mesh collider of the face model, it will paint preselected color on the face model in the same position as the user did in the real world.

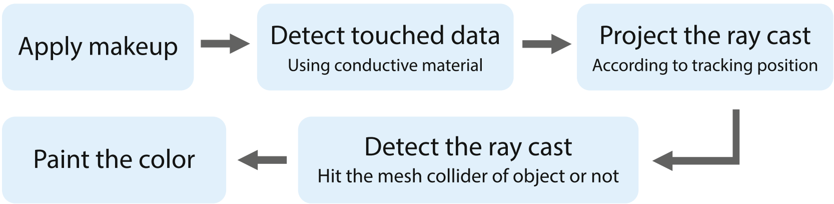

Fig. 7. The workflow of face painting process

4 Evaluation

A subjective evaluation was conducted to evaluate the user satisfaction and the performance of the system. Five subjects were asked to apply makeup by using our system. The subjects have to use our makeup tools, which include lipstick, eyebrow pencil, and cheek brush. The subjects can choose their own makeup color and try to apply the makeup in their own style. While the subjects apply the makeup on their face, the monitor will display corresponding makeup result on the face model in real-time as depicted in Fig. 9. Finally, the interval scale questionnaires, as shown in Fig. 8, were given to the subjects to ask about their satisfaction after they have used our makeup system.

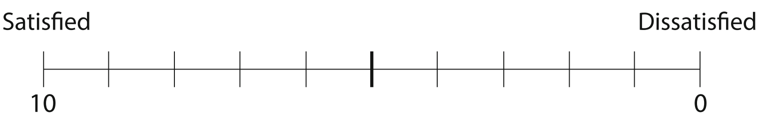

Fig. 8. The example of interval scale questionnaire

Fig. 9. The subjects applied a virtual makeup by using our system

Fig. 10. The makeup result

5 Result and Discussion

Figure 10 shows the makeup results. The evaluation results were separated into 2 parts; tools evaluation, and overall system evaluation. Figure 11(a) shows the evaluation result of each makeup tools. The graph shows user satisfaction level of the brush shape and the color tones of each makeup tools. The comfortable level of a tactile sensation when subjects used our mock-up tools compare with real cosmetic tools also shows in this graph. As can be seen, most subjects are satisfied with the shape, the color tone, and the tactile sensation of the cheek brush. They think that it provides a realistic makeup on their face model. Also, it can make them feel comfortable and give them a realistic makeup feeling when they apply the makeup because our brush tool made from the real brush material.

However, the satisfaction level of the brush shape of the eyebrow pencil is less than 50% because they feel that the thickness of a line is too thick when they are shaping the eyebrow, so it is difficult to control and paint their eyebrows in the desired shape. The comfortable level of the tactile sensation of eyebrow pencil and lipstick also less than cheek brush because both of them made from resin which is a hard material, so it provides a less realistic tactile sensation to the subjects compare with the real makeup tools.

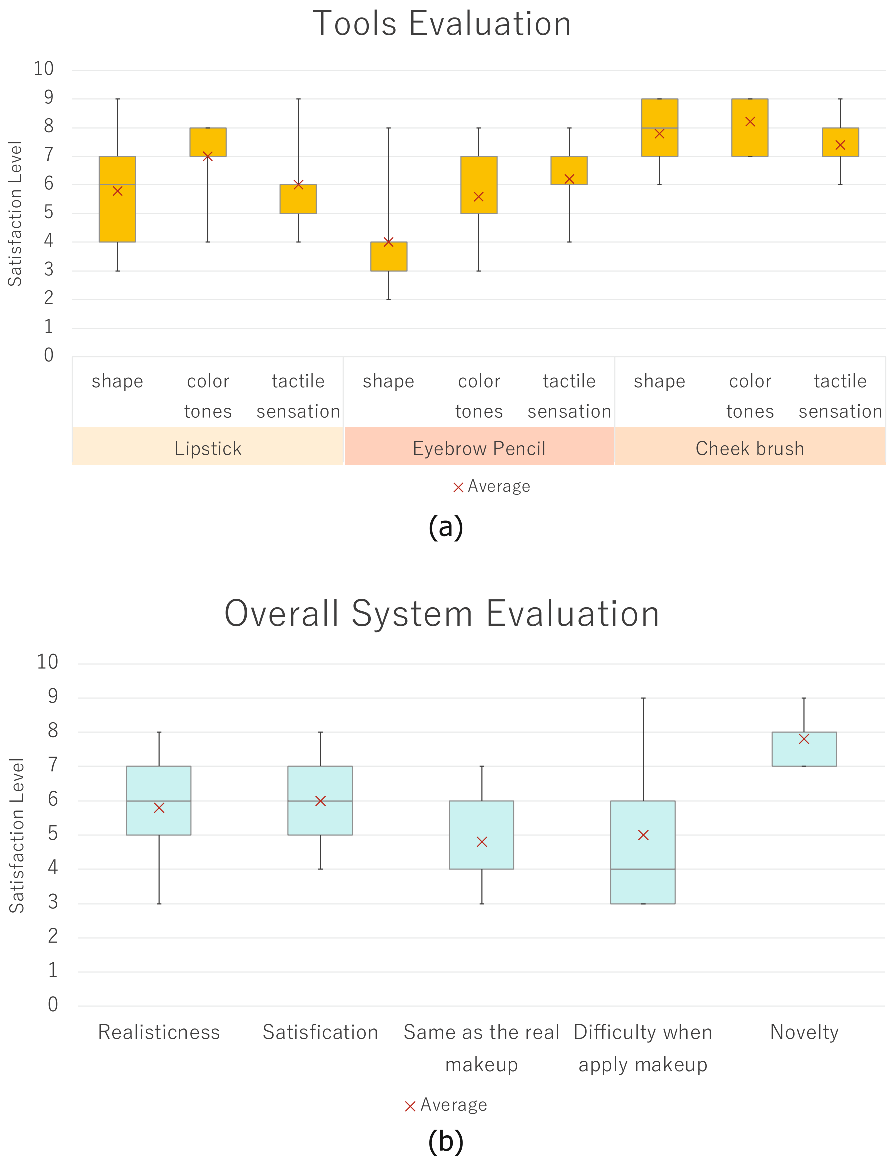

Fig. 11. The subjective evaluation result (a) Tool evaluation, and (b) Overall system evaluation

Figure 11(b) shows the evaluation result of the overall system. It is apparent that most subjects think our system is creative and provide them a new feeling with virtual makeup. The evaluation result demonstrates that our system provides a realistic feeling to the subjects and they are satisfied with our system at 60% average. Nevertheless, the system is quite difficult to use because if there are any objects blocking the tools from the camera viewpoint or the user hold a tool in the wrong orientation, then it will decrease the tracking efficiency of our system. Also, most subjects feel that our system does not provide the same feeling as the real makeup due to the limitation of the camera viewpoint that does not allow the them to realistically handle the tools.

6 Conclusions

In summary, we have presented a novel augmented virtuality face makeup system for the propose of providing an interactive makeup feeling to the users.

By collecting the user's comment after they try to apply the virtual makeup with our system, their satisfaction with the system is around 60% average. Most of them think that our system gives them a new makeup experience and offers an interactive feeling than previous makeup applications. However, there are some limitations in our system. First, the distance between the users and the camera should not be too close and the camera should not be blocked by any objects because the reflected light of the object can affect the infrared image, which will increase noises and decrease the efficiency of the tool tracking part of the system. Moreover, we have to improve the quality in the painting step such as the line thickness and the color tone of the eyebrow pencil for providing a more realistic makeup result.

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